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Technical Note

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EDDY CURRENTS IN THE TRANSITION JUMP QUADRUPOLE VACUUM CHAMBERS

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Introduction

A fast transition jump is being installed in the AGS. Quadrupoles located in the "17" straight sections of the A, C, E, G, I, and K superperiods will be excited with a 60 msec risetime. This will raise the AGS transition energy by about 3 GeV. The transition energy will then be abruptly lowered during a 500 μsec de-excitation as the AGS itself passes through transition. The effect of these manipulations will be to speed up passage through transition by a factor of 30 to 100 if the magnetic fields in the quaddrupoles follow the excitation currents. This will drastically lower beam losses at this inherently unstable point. However, eddy currents induced in the vacuum chamber by the rapid de-excitation will reduce the amount of speed up. The purpose of these studies was to investigate the effects of eddy currents in the vacuum chamber on the pulsed magnetic field in a transition jump quadrupole.

Procedure

A simplified electrical schematic is shown in Figure 1a, and the mechanical arrangement is illustrated in Figure 1b. However, a prototype of the GTO switch which will be used in final installation was used for these tests. The quadrupole was energized to 3000 A by closing the switch (since R >> r, little current flows in resistor). Upon opening the switch, the current was diverted to the bypass resistor and the quadrupole field decayed. An air core pick-up coil was placed in the magnet, about 1" from a pole tip, and the voltage induced in this coil during the decay was displayed on an oscilloscope. The mechanical configuration was such that the coil did not have to be disturbed in order to change the 2′-3′ sections of vacuum pipe which were used in these tests.

Results

Figure 2a is a photograph of the oscilloscope showing current in R and the coil voltage with no vacuum pipe. The pick-up coil (which is sensitive to dB/dt), gives a maximum output of 6.210 V at no delay, Δ, after $(di/dt)_{max}$. Figure 2b shows similar data, but for a 0.125" aluminum pipe. The maximum coil output is 0.550 V, which occurs 1,000 μsecs after the maximum di/dt. Table I summarizes all the data which we have taken.

TABLE I
Eddy Current Data

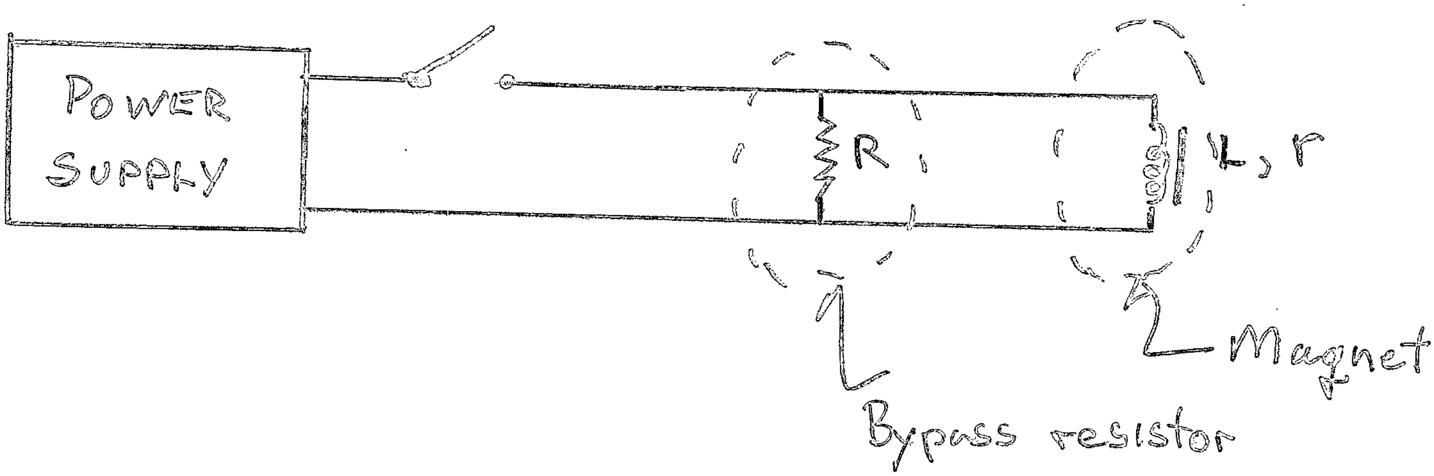
Pipe Material	V_{max} (V)	$V_{max}/V_{max\ air}$	Δ (μsecs)
Air	6.210	1.0	0
0.020" Inconnel	5.57	0.90	0
0.025" Stainless	4.70	0.76	50
0.062" Stainless	4.24	0.68	100
0.125" Aluminum	0.55	0.09	1000

Conclusions

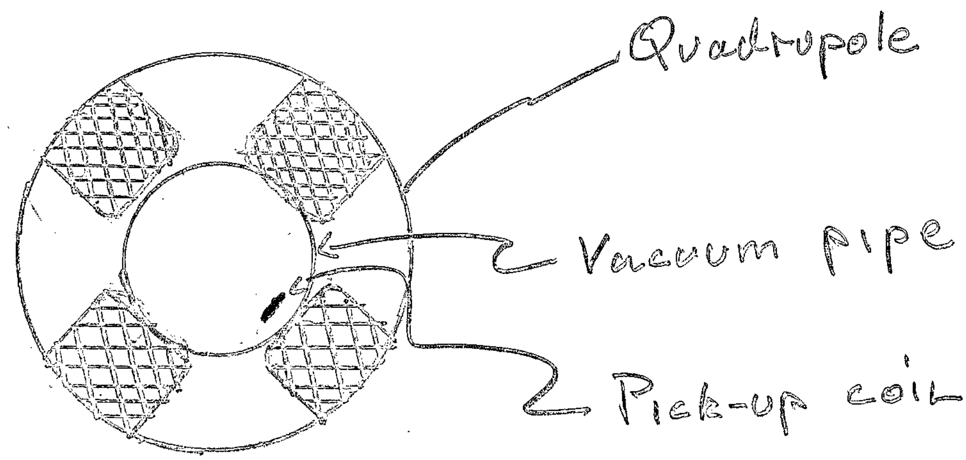
We conclude that the use of the present AGS vacuum chambers, which are 0.062" stainless steel, will degrade the speed of the transition jump by approximately 32%. This is acceptable for the short term. However, in order to achieve the maximum benefits from the system, it would be desirable to go to a thin Inconnel chamber.

Acknowledgments

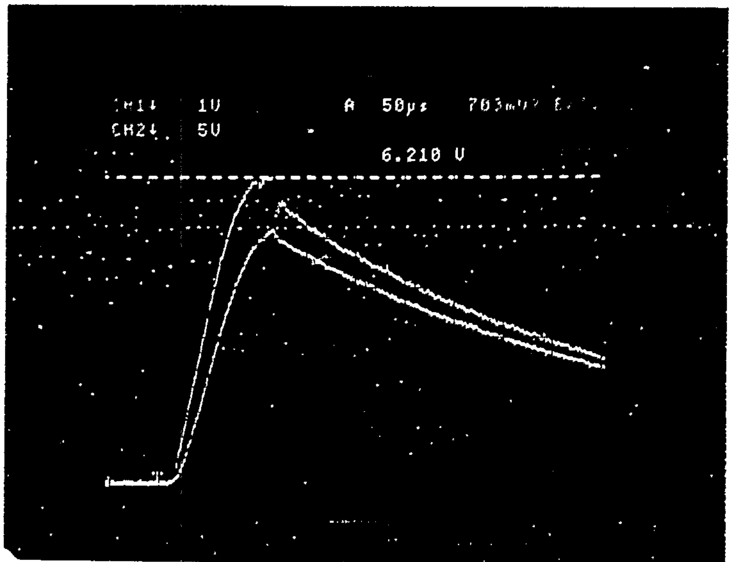
We would like to thank E. Rodger and K. Welch for supplying some of the vacuum chambers. The design of the GTO pulser is due to K. Hughes.


POWER SUPPLY
R
L, r
Magnet
Bypass resistor

(a)

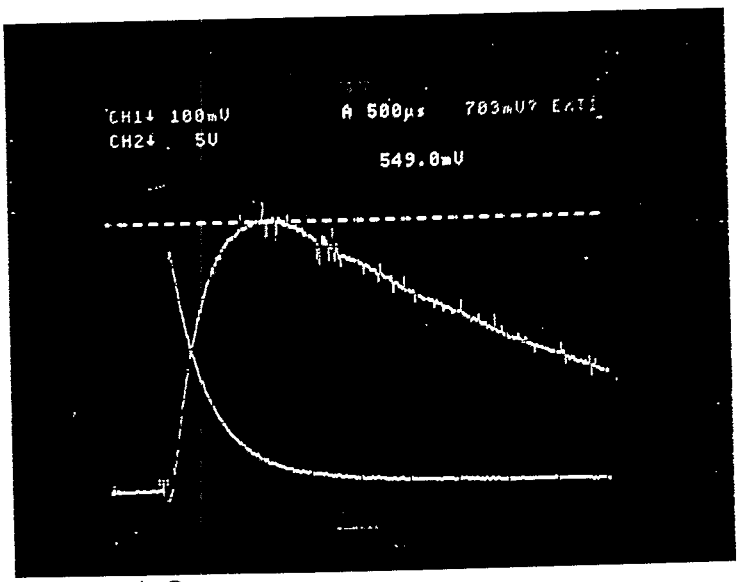

Quadrupole
Vacuum pipe
Pick-up coil

(b)



AIR 3000A B 6.21V

(a)



1/2" Al

(b)

Fig. 2